UNIVERSITI TEKNOLOGI MARA

NONLINEAR IDENTIFICATION OF STEAM DISTILLATION PILOT PLANT

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Thesis submitted in fulfillment
of the requirements for the degree of
Master of Science

Faculty of Electrical

October 2015

AUTHOR'S DECLARATION

I declare that the work in the thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the result of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Riles and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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ABSTRACT

This thesis presents the new approach of nonlinear system identification on steam temperature of distillation column. The system identification is initialized with a step test to study the behavior of steam distillation column before continuing with Pseudo Random Binary Sequence (PRBS) input. Four types of perturbation signals have been presented in this thesis, where the PRBS is first signal was injected to the distillation column, and followed by Multi-level Pseudo Random Sequence (MPRS), Multi-Sine (MSine) and Random Gaussian Signal (RGS) inputs respectively. The collected data from various perturbation environments were then pre-processed and analyzed to evaluate their power spectral density, bode and data distributions. In identification of steam distillation pilot plant driven by PRBS input, the Auto-Regressive with Exogenous Input (ARX) and Nonlinear Auto-Regressive with Exogenous Input (NARX) model structures have been used to model the system dynamic. The selection of model order for both structures was made based on Akaike's Information Criterion (AIC). The selected ARX and NARX structures were estimated and validated. The performances of both models were then further assessed by OSA evaluation test. Results have shown that the NARX models are slightly better than ARX models, however it still insufficient in identifying a nonlinear system dynamic. It clearly seen that the R^2 and RMSE shows insignificant improvement from the ARX to the NARX models and unable to reveal that the NARX model is outperforming the ARX model. Subsequently, steam distillation pilot plant is driven by MPRS, MSine and RGS perturbations to develop the ARX and NARX structures to model the system dynamic. The same approaches have been applied, which is selection of model order was made based on AIC criterion and proceed for One-Step-Ahead (OSA) evaluation test. The transformation of three perturbation signals; MPRS, MSine and RGS as input to steam distillation column by replacing the PRBS perturbation exhibit significant improvement to nonlinear system identification. The nonlinear system identification is applied via the NARX approach is capable in estimating the nonlinear system behavior. The statistical evaluation; R^2 and RMSE reveal significant improvement achieved by NARX over ARX models. The residual of NARX models shows the adequacy of the fitted model. In addition, the OSA prediction revealing the presence of underlying dynamics is entirely captured by the NARX model.

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